ECOLOGY OF THE HALOPHILIC VEGETATION OF THE PANNONICUM IV. INVESTIGATIONS ON THE SOLONETZ MEADOW SOILS OF OROSHÁZA

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The deepest levelled regions of our territory separate obviously from the extremely alkaline solonetzes of their environment, with a view both to vegetation and to soil research. The causes of this difference may be looked for mainly in the different hydrographic relations. These territories which are covered with water in a great part of the year are exposed to an increased alkalization, thus the accumulation of salts and the progress in the process of becoming solonetz are of a much smaller degree.

The formation of these more favourable soil conditions can be explained also by the fact that the primary solonetz strata, together with the level of salt accumulation, fell victim to the eroding function of subsoil waters, and the present surface strate may have been formed from the BC-levels of solonetzes in ancient ages. Thus the solonetz subtypes, forming besides mosaic complexes, and the halophilic vegetation produced on them show a zonal arrangement on soils of meadow character.

6. Pholiuro-Plantaginetum tenuiflorae (RAPAICS, 1927), WENDELB., 1943.

The transitory zone of solonetzes and of the meadow soils becoming solonetz, as well as the muddy bottom of solonetz-depressions presenting a mosaic-lice arrangement are taken up by an alkaline mud-association (Fig. 4). Depending upon the duration of spring inundation by subsoil-water and alkaline degree of soil there may be separated the following sub-association units:

a) *Pholiuro-Plantaginetum tenuiflorae myosuretosum* BODROGK. 1964.

In the years in which the June maximum of the atmospheric precipitation takes a shape or the season of spring is adequately rainy, like from the six investigation years those of 59, 61 and 63 were, there could widely be observed not only the *Matricaria chamomilla* (MÁTHÉ 1962) and the halophilic ephemerous species of genus *Trifolium* but also the mudplants of alkaline soils and thus the above-mentioned subassociation, as well. Its differential species come out of elements of *Puccinellion, Puccinellietalia,* resp. *Nanocyperion: Myosurus minimus, Crypsis aculeata, Lythrum hyssopifolia* (Table I, Nos. 1—3).

Table I. **PHOLIURO-PLANTAGINETUM**

Subassociation:	*Myosurus minimus*			*Plantago tenuiflora*				
No.:	1	2	3	4	5	6	7	8
Covering of lawn-level in %:	50	60	60	40	50	45	45	60
Research territory in m²:	15	20	15	25	20	25	25	20
Whole number of species:	10	9	7	10	6	3	8	4
Number of soil-profile:	—	—	—	—	—	—	—	—
LAWN-LEVEL								
Kinds of association-charakter								
Pholiurus pannonicus	1—2	2	2	2—3	3	3	2—3	3—4
Plantago tenuiflora	+	.	.	1—2	1	2	1—2	1
Myosurus minimus	3	3	3	+—1	.	+	+	.
Species Puccinellion:								
Puccinellia distans ssp. limosa	.	.	.	+—1	1	.	+	1
Camphorosma annua	.	.	.	.	.	.	1	.
Crypsis aculeata	1—2	1	.	.	.	.	.	.
Species Puccinellietalia:								
Matricaria chamomilla v. salina	1	+	1—2	+	+	.	+	.
Eleocharis uniglumis	+—1	1—2	.	1—2	1	.	2	.
Cerastium dubium	.	.	1	.	.	.	.	.
Lepidium ruderale	.	.	.	.	.	.	.	.
Hordeum hystrix	.	.	.	.	.	.	.	.
Carex stenophylla	.	.	.	.	.	.	.	.
Species Nanocyperion, Agrostion and Beckmannion:								
Rorippa silvestris ssp. kerneri	1	+	+—1	+	1	.	+	.
Alopecurus pratensis	+—1	+	+—1	.	.	.	.	.
Lythrum hyssopifolia	+—1	.	+	.	.	.	.	.
Beckmannia eruciformis	.	.	.	+—1	.	.	.	+
Species Festucion pseudovinae:								
Scorzonera cana	.	.	.	.	.	.	.	.
Limonium Gmelini	.	.	.	.	.	.	.	.
Festuca pseudovina	.	.	.	.	.	.	.	.
Artemisia maritima ssp. monogyna	.	.	.	.	.	.	.	.
Neutral species:								
Polygonum aviculare	.	+	.	.	.	.	+	.
Mentha pulegium	.	+	.	+	.	.	.	1
Gypsophila muralis	.	.	.	.	.	.	.	.
MOSS LEVEL								
Nostoc commune	1	.	1—2	1	.	.	.	

TENUIFLORAE

Polygonum aviculare				*Puccinellia limosa*							
9	10	11	12	13	14	15	16	17	18	19	20
65	80	70	60	50	65	50	60	85	60	60	75
25	25	30	15	30	30	25	35	20	30	25	25
11	10	9	10	12	9	8	13	8	12	12	13
—	255	—	—	—	—	—	217	225	227	231	244
2—3	2	2	2	2	3	2	2	3	2	2—3	2
1	1	1—2	1	1	1	1	1—2	+—1	1	+—1	1
	.	.	.	+	+	.	1	.	.	.	.
1	1	.	+	2—3	2	2—3	2—3	3	2—3	2	3
	.	.	.	.	1	.	.	1	.	+	+
	.	.	.	.	.	.	.	.	+	.	.
	1	1	1—2	+	.	+	.	.	.	+—1	+
.	+	1	.	.	+	.	.	1	1—2	.	+
+	.	1	+	+	.	.	+	.	.	.	.
+	.	1	+	+	.	.	+	.	.	.	.
.		+	+	.	.	.	+	.	+	+	+—1
.	.	.	.	1	+	1	+	+	.	.	+—1
.	.	.	.	.	.	+	+	.	1	1	.
1	1	.	.	.	.	.	.	.	.	+—1	.
.	.	.	.	.	.	.	.	.	+	.	.
.	.	.	.	.	.	.	.	.	.	.	.
1		+—1	+	+	.	.	.	.	+	+—1	+
.	+	.	.	+	.	.	.	.	+—1	1	1
+		+	.	1	.	.	+	.	.	.	.
.	.	.	.	+—1	.	.	.	+	.	.	.
3	3—4	3	3	.	1	+	1	+	1—2	1	1
+	1	.	1	.	.	.	.	.	+	.	.
+	.	.	+	.	.	.	+	.	.	.	+
2	1—2	.	.	1—2	2	1—2	2	.	.	.	2

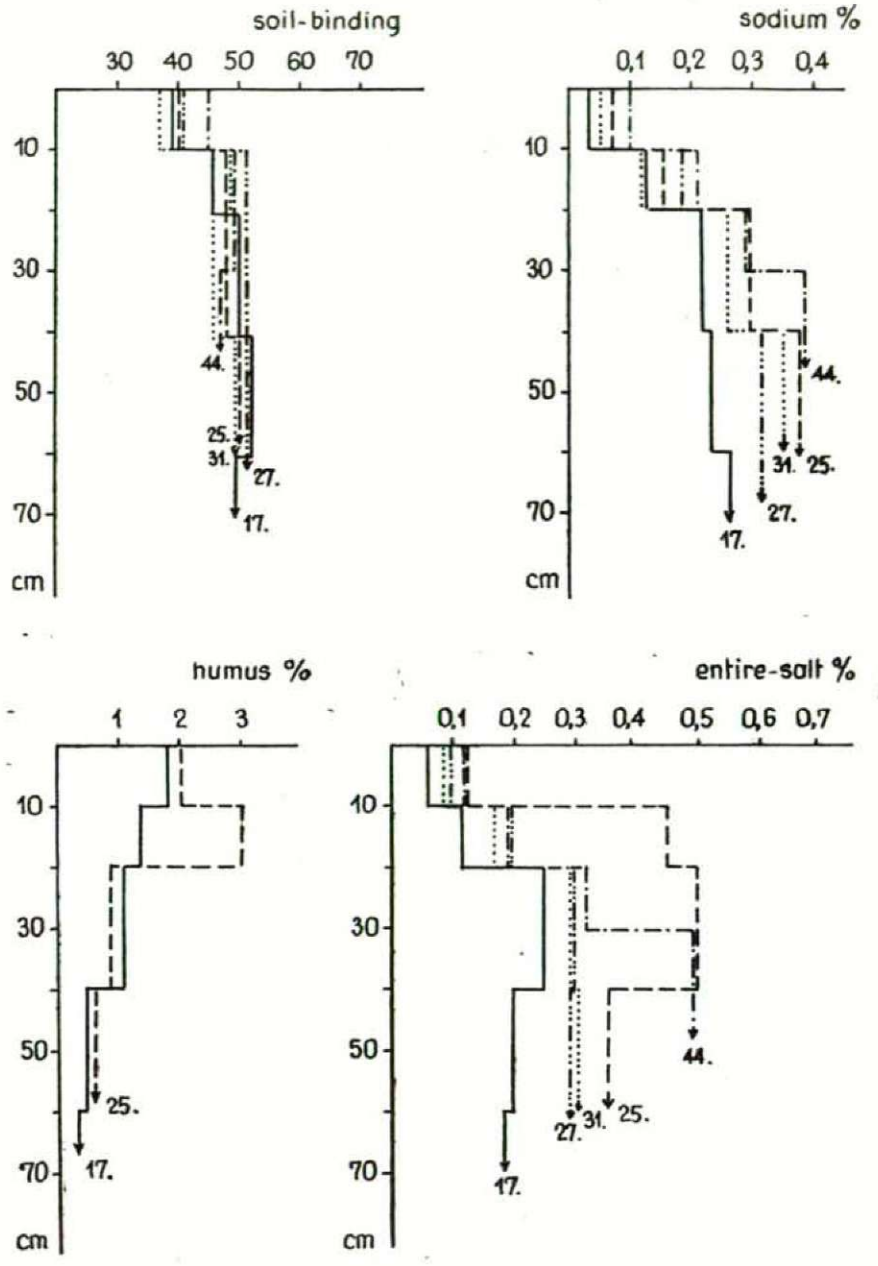

Fig. 1. Changes of the soil-chemical features of PHOLIURO-PPANTAGINEUTUM TENUIFLORAE PUCCINELLIETOSUM in different soil levels.

Its soil is, like the Hortobágy occurrence, a muddy meadow solonetz, strongly alkalized.

a_1) *Pholiuro-Plantaginetum myosuretosum Alopecurus pratensis facies.*

It is in zone of solonetz and meadow soils, showing a transition to *Agrosti-Alopecuretum.* Thus there increase considerably the dominance values of the elements *Agrostion* and *Beckmannion* and mainly the covering of *Alopecurus pratensis.*

b) *Pholiuro-Plantaginetum tenuiflorae plantaginetosum (=typicum)* Soó (1933) 1964.

The soil of its growth differs from the first sub-association mainly in humidity. In our territory it could not be separated from *pholiuretosum* (Soó 1964).

c) *Pholiuro-Plantaginetum polygonetosum avicularis* Soó 1933.

The soil of its growth becomes later gradually drier; apart from halophilic species, mainly neutral, facultative halophyts become dominating. Its differential species in our territory are: *Polygonum aviculare, Mentha pulegium, Limonium Gmelini.* The latter may sometimes form even facies (Table I, Nos. 9—12).

Its soil is muddy meadow solonetz, moderately alkalized.

d) *Pholiuro-Plantaginetum tenuiflorae puccinellietosum limosae* Bodrogk. 1964.

It shows a transition towards the *Puccinellietum limosae* of crusty solonetz zones. Thus the alkaline degree of its soil is higher than that of the soil of the former subassociation, therefore it can be considered as a meadow solonetz weakly alkalized. Graphs appreciating the detailed results of its investigation take place in Fig. 1.

Its differential species are: *Puccinellia distans ssp. limosa,* and *Carex stenophylla.* In drier circumstances, apart from the latter, there occur also: *Hordeum hystrix, Matricaria chamomilla, Scorzonera cana, Limonium Gmelini, Artemisia maritima ssp. monogyna.* Steppe processes being advanced, the initial state of *Artemisio-Festucetum pseudovinae* will appear in this region (Table I, Nos. 13—20).

7. Agrosti-Alopecuretum pratensis Soó (1933) 1947.

It appears in the regions of our alkali soils in Orosháza that remain, because of their flat situation, of wet soil until the end of May (Fig. 6, Table I). Its coenological relations are functions of the degree of soil humidity and of its becoming solonetz.

a) *Agrosti-Alopecuretum (typicum=) eleocharetosum uniglumis* Bodrogk. 1964.

In regions of flat places, being free, for the time being, from steppe processes, where, in consequence of favourable water-supply, *Drepanocladus aduncus* and *Eleocharis uniglumis* may occur as differential species. Further details concerning its species-combinations are contained in Table II, Nos. 1—5.

a_1) *Agrosti-Alopecuretum eleocharetosum Beckmannia facies.*

It appers in wettest parts of alkali meadows with *Alopecurus* and forms a trasition towards the meadows with *Beckmannia.* Detailed results of investigations concerning its soil take place in Fig. 2.

Distribution on annual rainfall in the years of investigations in the major phases of the development of vegetation:

Table II. **AGROSTI-**

Subassociation:	*Eleocharis*								*Ty*
No.:	1	2	3	4	5	6	7	8	9
Covering of lawn-level in %:	100	95	190	85	100	90	100	80	90
Research territory in m²:	25	30	30	25	35	30	25	25	25
Whole number of species:	10	9	9	10	9	11	14	16	9
Number of soil-profile:	224	261	236	222	216	.	259	—	—
LAWN-LEVEL									
Kinds of association-charakter:									
Alopecurus pratensis	3	2—3	3—4	3—4	1—2	3	2	3	4
Rorippa silvestris ssp. kerneri	+	1	1	1	2	+	+—1	1	1—2
Agrostis alba	2	1	+	1	3—4	3	2—3	1	+
Beckmannia eruciformis	1—2	1	.	+—1	+	.	.	.	+
Oenanthe silaifolia	+	.	+	.	.	+	3	.	.
Species Juncion gerardi:									
Juncus compressus	.	.	.	.	.	+	+	.	.
Trifolium fragiferum	.	.	.	.	.	+—1	.	.	.
Lotus corniculatus ssp. tenuifolius	.	.	.	.	.	.	1	.	.
Species Festucion pseudovinae:									
Limonium Gmelini	+	.	.	.	.	.	+	+	.
Scorzonera cana	.	.	+	.	.	.	.	.	+
Festuca pseudovina	.	.	.	.	.	.	.	+	.
Artemisia maritima ssp. monogyna	.	.	.	.	.	.	.	.	.
Species Puccinellion:									
Puccinellia distans ssp. limosa	.	.	.	.	.	.	.	.	.
Plantago tenuiflora	.	.	.	+	.	.	.	.	.
Myosurus minimus	.	.	.	.	.	.	.	2	+
Pholiurus pannonicus	.	.	.	.	.	.	1	.	.
Species Puccinellietalia :									
Cerastium dubium	.	.	.	.	.	.	.	1—2	.
Eleocharis uniglumis	3	3	2—3	2	2	1	+	.	1
Hordeum hystrix	.	.	.	+	.	.	.	.	.
Carex stenophylla	.	.	.	.	.	.	.	+	.
Matricaria chamomilla var. salina	.	.	.	.	.	.	.	.	.
Ranunculus lateriflorus	.	.	.	.	.	1	.	1	1
Species Bolboschoenion:									
Bolboschoenus maritimus	.	.	.	.	1	+	.	.	.
Species Molinio-Juncetea, Arrhenatheretea and Agrostion:									
Taraxacum officinale	.	.	.	.	.	.	.	+	.
Trifolium repens	.	.	.	.	.	.	.	.	.
Potentilla reptans	.	.	.	.	.	.	.	.	.
Medicago lupulina	.	.	.	.	.	.	.	.	.

ALOPECURETUM PRATENSIS

p i c u m							*L i m o n i u m*								
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
190	80	100	80	85	90	90	95	75	100	100	95	80	100	80	95
35	35	30	25	30	25	25	30	30	25	25	20	25	25	30	35
12	15	19	9	12	5	8	14	14	13	12	14	10	10	10	16
—	—	—	—	223	—	—	245	—	235	240	—	246	—	—	—
3	3	3—4	2—3	2	2	2	3	2—3	3	2	2	2—3	2	2	2
1	1—2	.	+	.	+	+	.	+	1	1	+—1	.	.	1	+
+	.	.	.	+	.	.	+	.	1	1	+	.	.	1	.
.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
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.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	+—1	.	.	.	.	.	.	.	.	.	.	.	.	.
.	+	.	+	+	.	+	2—3	2—3	3	3	3	1—2	2	1—2	2
.	.	+	+	+	+—1	1	.	+	1	2	2	+	+—1	+—1	1
1	+	+	.	.	.	.	.	1—2	+	+—1	+	+	.	.	1
.	.	.	.	.	.	.	1	.	.	.	.	3	3	.	+
.	.	.	.	+	.	+	.	.	.	.	.	1—2	1	3	3
.	.	.	+	1	.	+—1	+	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
.	.	.	.	+—1	.	.	.	.	.	.	.	.	.	.	.
1	1—2	.	.	.	.	.	+	1	+—1	+	1	+	+	+	1
.	.	.	.	+	.	+	.	1	.	.	.	.	.	.	.
.	.	.	+	+	.	.	+	.	.	.	.	+	+	.	+
1	1	.	.	.	.	.	+	.	+	.	+	.	.	.	.
.	.	.	.	.	.	.	+	+	1	.	.	+	+—1	.	1
.	.	.	.		.	.	+	1	+—1	+	1	+	+	+	1
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	1	1	.	.	.	.	+	.	.	.	.	.	.	.	.
2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.
.	1	2—3	.	.	.	.	.	.	.	.	.	.	.	.	.
+—1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.

Table II.

Subassociation:	*Eleocharis*								*Ty*
No.:	1	2	3	4	5	6	7	8	9
Covering of lawn-level in %:	100	95	190	85	100	90	100	80	90
Research territory in m²:	25	30	30	25	35	30	25	25	25
Whole number of species:	10	9	9	10	9	11	14	15	9
Number of soil-profile:	224	261	236	222	216	.	259	—	—
Species Festucetalia valesiacae and Festuco-Brometea:									
Poa bulbosa var. vivipara	.	.	.	.	.	.	.	.	.
Erophila verna	.	.	.	.	.	.	.	+	.
Myosotis micrantha	.	.	.	.	.	.	.	+	.
Achillea millefolium ssp. collina	.	.	.	.	.	.	.	.	.
Poa pratensis ssp. angustifolia	.	.	.	.	.	.	.	.	.
Plantago lanceolata	.	.	.	.	.	.	.	.	.
Medicago falcata	.	.	.	.	.	.	.	.	.
Species Onopordion and Onopordetalia:									
Trifolium striatum	.	.	+	.	.	.	.	.	.
Cichorium intybus	.	.	.	.	.	.	.	.	.
Lactuca serriola	.	.	.	.	.	.	.	.	.
Neutral species:									
Mentha pulegium	+	+	1	1	1	+	1	.	.
Polygonum aviculare	+	1	+—1	+—1	1	.	.	+—1	+—1
Inula britannica	.	.	.	.	1—2	.	.	1	.
Gypsophila muralis	.	.	.	.	.	.	.	.	.
Lolium perenne	.	.	.	.	.	.	.	.	.
MOSS LEVEL									
Nostoc commune	2	.	.	.	.	.	.	1	.
Drepanocladus aduncus	.	1	.	1—2	2	.	.	.	.

Acidd. species:

Magnocaricion:	*Carex melanostachya*	7 : 1—2
	Veronica scutellata	7 : +
Nanocyperion:	*Lythrum hyssopifolia*	6 : +—1
Molinietalia:	*Lysimachia nummularia*	7 : 1
	Juncus articulatus	2 : +

Puccinellia							*Limonium*								
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
190	80	100	80	85	90	90	95	75	100	100	95	80	100	80	95
35	35	30	25	30	25	25	30	30	25	25	20	25	25	30	35
12	15	19	9	12	5	8	14	15	13	12	14	10	10	10	16
—	—	—	—	223	—	—	245	—	235	240	—	246	—	—	—
.	.	.	.	.	.	.	.	+	1	.	+	1	1	.	1
+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+
.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.
.	.	.	.	.	.	.	2	.	+	.	1—2	.	2	.	.
.	.	+	1	.	+	.	.	.	.	.	.	.	.	.	.
.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.
.	.	1—2	.	+	.	.	.	+	.	.	+	.	.	.	+
.	.	.	3	4	4	4	.	+	.	.	+	.	.	.	+
2	+—1	1	1	.	.	.	1	1	+	2	1	.	.	+	+
.	.	.	.	.	.	.	.	+—1	.	+	+	.	.	.	.
.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	2	.	.	.	.	.	.	.	+	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Molinio-Juncetea:
Convolvulion:
Rud.-Secalinetea:

Ranunculus acer 7 : +
Scutellaria hastifolia 7 : 1—2
Convolvulus arvensis 2 : 1
Agropyron repens 24 : 1

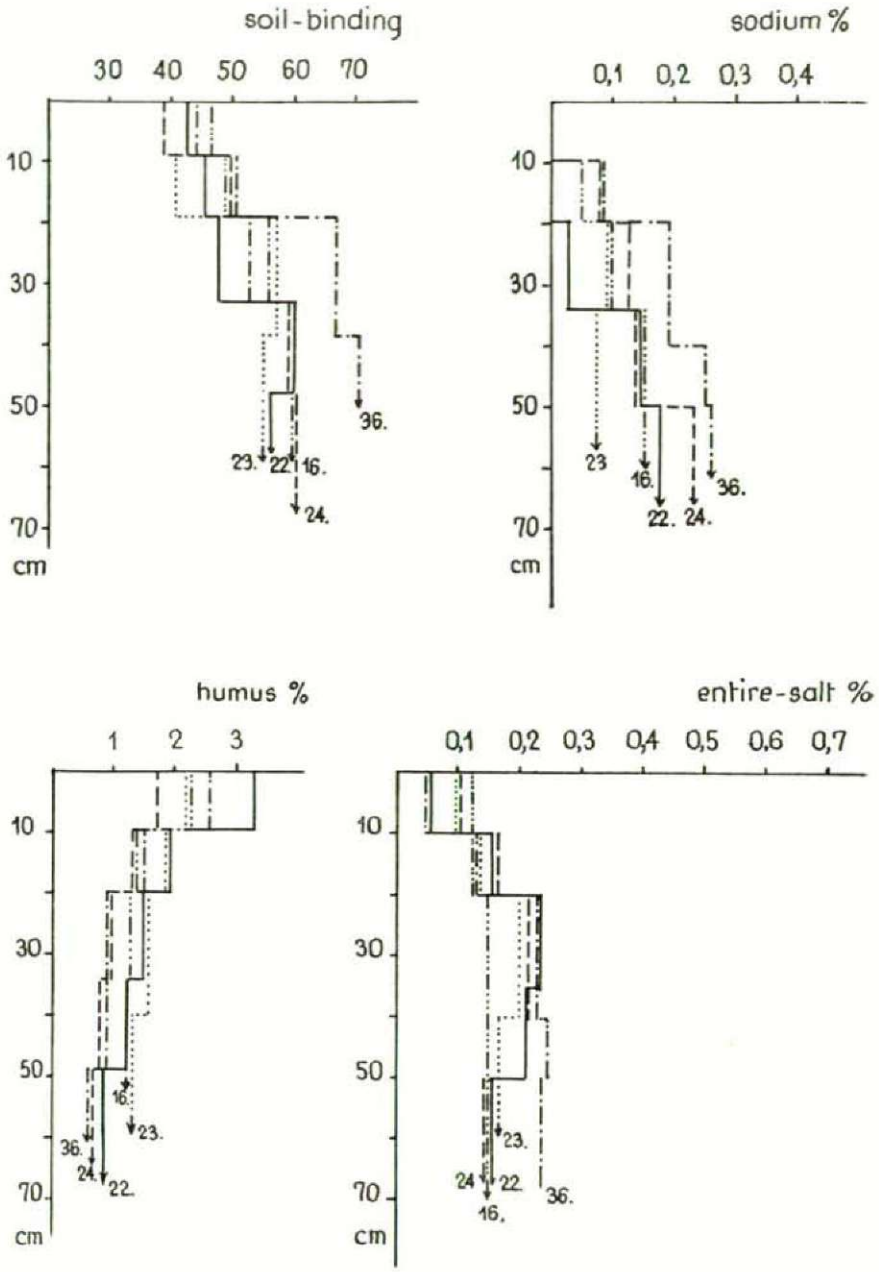

Fig. 2. Result of the basic soil-physical and soil-chemical investigations of AGROSTI-ALOPECURETUM TYPICUM.

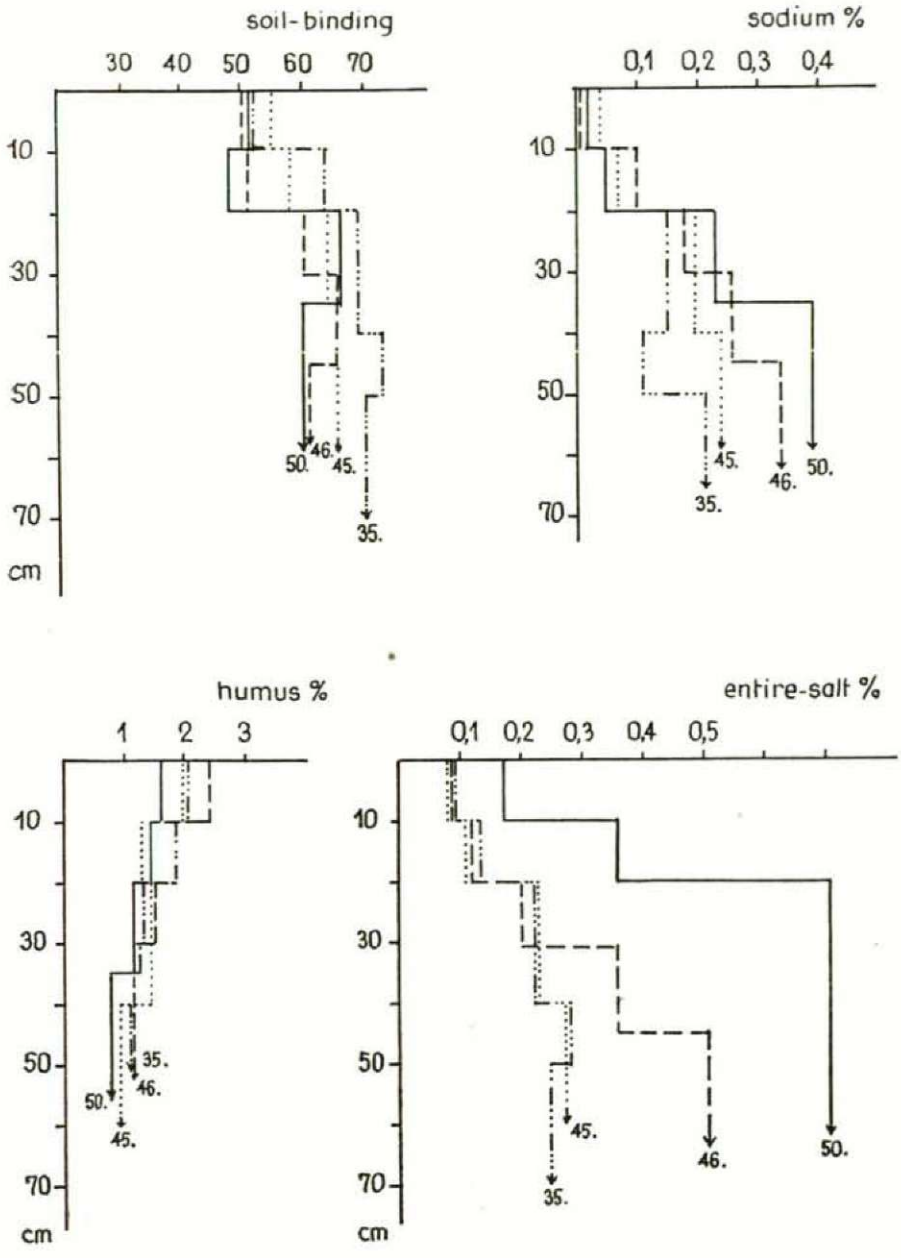

Fig. 3. Graphs indicating the soil-investigation result of AGROSTI-ALOPECURETUM LIMONIETOSUM.

Year	Jan. 1–March 31	Apr. 1–15	Apr. 15–30	May 1–15	May 15–31	Jun. 1–30	Jul. 1–Aug. 31	Sept. 1–Dec. 31	Summary
1959	68,7	13,9	16,1	78,3	4,5	108,6	66,2	137,4	493,7
1960	100,7	14,6	20,6	7,7	30,7	36,3	46,9	190,6	448,1
1961	60,9	5,4	39,5	12,4	87,6	61,6	63,9	100,4	431,7
1962	123,8	17,7	0,3	1,8	17,5	20,8	89,0	130,6	401,5
1963	120,8	18,3	3,4	24,9	23,4	25,9	111,8	242,3	570,8
1964	66,7	8,4	35,5	24,2	11,9	59,7	123,5		

b) *Agrosti-Alopecuretum limonietosum* Bodrogk. 1964.

In the bordering zone of meadows with *Alopecurus*, after the steppe processes having been advanced, some species of *Festucion pseudovinae* appear as differential species: *Limonium Gmelini, Artemisia maritima ssp. monogyna Scorzonera cana.* The first two (b_1 and b_2) may often be even facies-forming ones (Table II, Nos. 17–23).

The process of development of the initial state of *Artemisio-Festucetum pseudovinae*, the entering order and dominance-relations of the several species can be well followed in the course of studying these items.

In years the rainfall distribution of which in spring aspect is propitious even some *Trifolium* species do proliferate, like *T. striatum* and *T. angulatum*, in a smaller degree: *T. ornithopodioides* (Publ. III, Fig. 2). These species endure an increased solonetz-effect only in suitable humidity-circumstances.

b_3) *Agrosti-Alopecuretum limonietosum Puccinellia limosa fac.*

It appears at the meeting-spot of *Puccinellia* and *Alopecurus* meadows, as a transitory association (Table II, Nos. 24–25).

Its soil conditions: A common peculiarity of the exploited sections of sub-association that the meadow soils, drying up in the consequence of functioning of the establishments of the inland-water arrangement, become gradually solonetzes in character. In B_1-level of their sections the well-developed columns are frequent, however the salt-stacking in the accumulation level is not considerable, as yet (Fig. 3).

c) *Agrosti-Alopecuretum festucetosum pseudovinae* (n. n.)

In regions drying up, where the process of becoming steppe has been starting, as a consequence of drying up, without, however, becoming solonetz, in the new associations the facultative halophytons and glycophytons come into prominence, the succession being *Achilleo-Festucetum pseudovinae*, and their soil develops towards meadow chernozem (Stefanovits, 1962).

8. Agrosti-Beckmannietum (Rapaics 1916) Soó 1933.

Like Hortobágy, also in our territory on the deepsituated flat places where the effect of the arrangement of inland — waters can less be felt, the spring soil-waters remain behind like stagnating waters for a long time forming coenoses. In region of Orosháza, their amounts of largest extension can be found on the flat places of „Fecskéspuszta".

Coenological relationships. Association- and groupcharacter species are, apart from *Beckmannia eruciformis, Rorippa silvestris ssp. kerneri, Rumex stenophyllus;* locally: *Oenanthe silaifolia, Myosotis sparsiflora.* In consequence of propitious humidity-conditions and a minor presence of solonetz-effect, there take place neutral and glycophilic species. There are, apart from the eponymous *Agrostis alba,* also *Lysimachia nummularia, Potentilla reptans.* A consequence of the abundant water-supply is appearance of the several species of *Phragmition, Phragmitetalia,* resp. *Magnocaricion* elements, like *Lysimachia vulgaris, Rorippa amphibia x kerneri, Butomus umbellatus.* At meeting of adjacent associations take place some transitory coenoses as sub-associations.

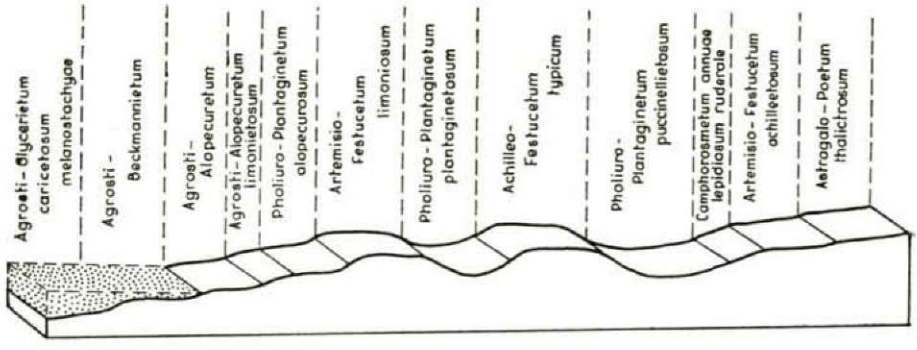

Fig. 4. The vegetation of solonetz soils shows a mosaic-like arrangement, that of meadow-soils with solonetz a zonal one (Sketch in profile from region „Fecskéspuszta", in Orosháza).

a) *Agrosti-Beckmannietum (typicum=) eleocharetosum* (n. n.).

The overwhelming majority of *Beckmannia*-meadows of our territories belong to this type of medows that are covered with shallow water during the entire vegetation period or having a fresh soil. Its differential species are: *Eleocharis uniglumis, Drepanocladus aduncus.* In its upper lawn-level *Beckmannia eruciformis* is always of high covering.

The sub-association may appear also as secondary, forming stocks in the water of drainage ditches.

Its soil is, during the woole year, owing to being covered with water in the major part of year, followed by intensive alkalization, a strongly alkalized meadow soil becoming solonetz, in the B_1 level of which, in the pillared layer, the salt accumulation can mostly be observed, in the B_2 level, however, the same as in the Hortobágy sections, it is insignificant. Therefore between *Agrosti-Alopecuretum typicum* and *Agrosti-Beckmannietum typicum* there is a major soil difference only concerning hydrographic conditions; the soil-ecologic differences are, having regard for alkalinity, not so significant as it might be found at the Hungarian classification. Detailed results of soil investigation take place in graphs of Fig. 5.

Table III. **AGROSTI-BECKMANNIETUM**

Subassociation:	*Typicum*												*Alopecurus pratensis*		
No.:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Covering of lawn-level in %:	25	40	35	35	25	30	25	30	30	35	25	25	25	30	30
Research territory in m²:	95	85	80	90	100	100	100	80	90	95	90	95	100	100	100
Whole number of species:															
Number of soil-profile:	—	—	—	215	252	37	—	—	—	—	—	—	—	254	253
LAWN-LEVEL *Kinds of association-charakter*															
Beckmannia eruciformis	3—4	3—4	3—4	3—4	3	3	2—3	3	3—4	4	3—4	3—4	2—3	3	3
Rorippa silvestris ssp. kerneri	1—2	1	1	.	+	+	+	+	.	+	1	1	1	.	1
Ranunculus lateriflorus	1—2	+	.	1	1	.	+	.	+	.	.	+	+	.	.
Rumex stenophyllus	.	.	+	.	+	.	+	1	+	1—2	1	1	.	.	.
Oenanthe silaifolia	.	+	1	.	+	.	.	.	.	.	.	.	.	.	1
Glyceria fluitans	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Species Juncion gerardi:															
Trifolium fragiferum	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Juncus compressus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+
Species Puccinellion and Puccinellietalia															
Eleocharis uniglumis	1	+—1	.	1—2	2	2	2	.	1—2	.	1	1—2	.	.	1
Cerastium anomalum	+	.	+	.	.	.	.	.	.	.	.	.	+	+	.
Myosurus minimus	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Species Bolboschoenion:															
Alisma lanceolata	.	.	+	+	+	.	+	.	.	.	.	.	.	.	.
Bolboschoenus maritimus	.	.	.	+—1	+	1	.	.	.	.	.	.	.	.	.
Species Phragmition-, Phragmitetalia and Magnocaricion:															
Schoenoplectus lacustris	.	.	.	2	1	1	.	.	.	1	.	1	.	.	
Lysimachia vulgaris	.	.	.	1	.	.	.	.	.		+	+—1	+	.	+

Rorippa amphibia x kerneri	.	.	.	.	.	.	.	.	+	+—1	.	.	2	.	.
Carex gracilis	2	.	.	1—2	.	.	.	.	.	.	.	.	.	.	+
Phragmites communis	.	.	.	1	.	.	.	.	.	.	+—1	.	.	.	.
Butomus umbellatus	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.
Rorippa amphibia	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.
Carex melanostachya	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.
Species Agrostion-, Molinion-, Molinio-Juncetea and Arrhenatheretea:															
Agrostis alba	1	2	2	1—2	3	3	3—4	2	1—2	2	2	1—2	1—2	2	1—2
Alopecurus pratensis	1—2	1	+	.	1	.	+	.	.	.	.	.	3	3	3
Lysimachia nummularia	.	.	.	.	.	.	.	+—1	+	1—2	.	1	.	.	.
Taraxacum officinale	+	+	+	.	.	.	.	.	.	.	.	.	+	.	.
Potentilla reptans	.	.	.	.	.	.	.	1	1—2	.	.	+	.	.	.
Ranunculus sardous	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1
Trifolium repens	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Species Convolvulion:															
Scutellaria hastifolia	1—2	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Species Festucion pseudovinae:															
Scorzonera cana	.	+	.	.	.	.	.	.	.	.	.	.	1	+	+
Festuca pseudovina	.	.	.	.	.	.	.	.	.	.	+	.	+	+	1
Limonium Gmelini	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+
Species Querceto-Fagetea:															
Veronica serphyllifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Neutral species:															
Inula britannica	.	+—1	.	.	.	+	+	1	+—1	1—2	1	.	+	1—2	2
Mentha pulegium	.	+	1	+	.	1	.	1—2	2	1	.	.	+	1	1—2
Polygonum aviculare	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.
MOOS LEVEL															
Drepanocladus aduncus	3	2	3	.	.	2	2	2	.	2	.	.	.	.	.
Nostoc commune	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.

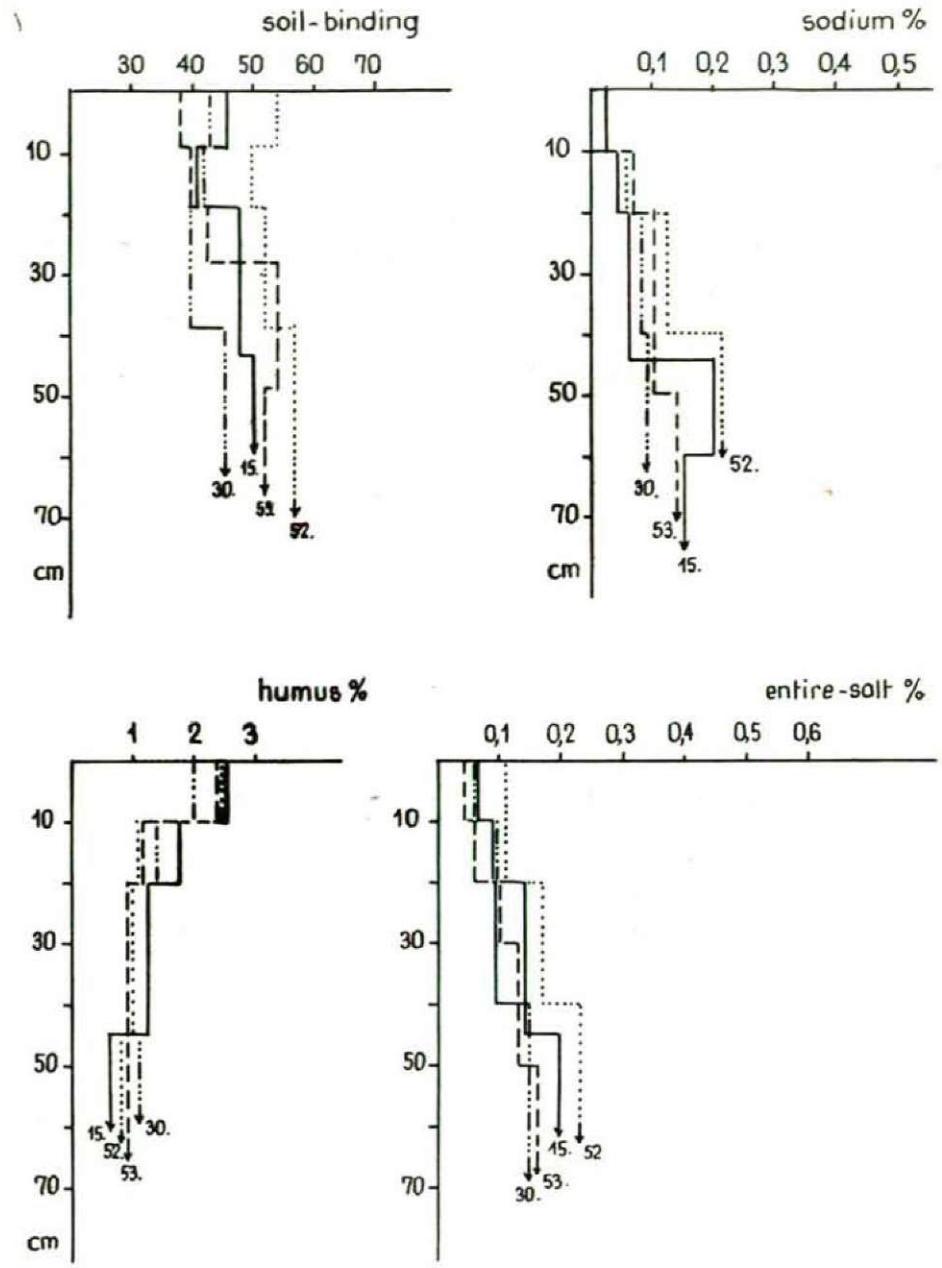

Fig. 5. Results of soil-investigation of AGROSTI-BECKMANNIETUM.

a_1) *Agrosti-Beckmannietum typicum Oenanthe silaifolia facies.*

It appears in the case of a propitious early summer rain distribution (as in three years of the investigated six ones) in the period of the first mowing.

b) *Agrosti-Beckmannietum alopecuretosum pratensis* Bodrogk. 1964.

In the neighbourhood of meadows with *Alopecurus* it forms the coenosis of the transitory zone. That zone dries often up and can be well differentiated from the type with its differential species, concerning not only soil ecology but also coenologic composition. These are: *Alopecurus pratensis, Juncus compressus, Ranunculus sardous, Trifolium repens, Scutellaria hastifolia.* Here and there even elements of *Fetucion pseudovinae* may occur. In the vicinity of formerly forest regions also *Veronica serpyllifolia* may appear occasionally, that can be considered as an element of *Querco-Fagetea* (Table III, Nos. 13—15).

9. Agrosti-Glycerietum poiformis Soó (1933) 1947.

There takes shape in the deepest flat places of our territory covered continually with water a zone of alkaline marshmeadows with *Glyceria.* It is already pressed back into small spots in consequence of the systematic inland drainages. Its species combinations come first of all from elements of *Phragmition* and *Magnocaricion* and become dominating besides the mass appearance of *Glyceria poiformis.*

It means a significant alteration in species-composition that *Eleocharis uniglumist* has been followed by the glycophilic *Eleocharis palustris.*

a) *Agrosti-Glycerietum poiformis (typicum=) eleocharetosum palustris* (n. n.).

Its differential species are, apart from the eponymous species, *Iris pseudacorus, Butomus umbellatus. — Schoenoplectus lacustris* (a_1), *Phragmites communis* (a_2), *Bolboschoenus maritimus* (a_3), may form facies.

Its soil is meadow-soil, in which the solonetz-forming processes can be demonstrated in a highly primitive state. Concerning the degree af alkalinity there does not take place generally any major difference from the former association. We have also here to look for the causes of the sub-association established in the field of hydrographic relations.

b) *Agrosti-Glycerietum poiformis caricetosum melanostachyae* (n. n.).

It forms mosaic-like complexes with the former sub-association. In its dense substance there appear *Carex melanostachya, C. gracilis, Gratiola officinalis* as differential species, being separated only by a step from the *Caricetum gracilis* of *Magnocaricion* group, proliferated in such a high degree in the flood plain of Tisza.

Its soil-ecology is characterized by that these sodgy spots have not but a minimal salt-content anymore and are to be considered, therefore, rather as meadowsoils. Thus the zone of *Carex melanostachya* means in the same time also the lower border of solonetz zones.

b_1) *Agrosti-Glycerietum (typicum=) Batrachium aquatilis facies.*

It appears in the open-water spots of marshmeadows with permanent water together with other hydatophyton species, as *Ceratophyllum demersum, Batrachium trichophyllum, Lemna minor, L. trisulca.*

b_2) *Agrosti-Glycerietum poiformis typicum Lysimachia nummularia fac.*

Ir these seedgy spots get quickly to a dry place for any reason, e. g., as a consequence of establishing lateral drain systems, the characteristic species of association go on existing for a while, and there appear recent elements, that here can be considered as differential species, as e. g., *Veronica scutellata, Mysotis sparsiflora, Oenanthe silaifolia, Mentha pulegium Lysimachia nummularia,* which can tolerate, for a short time, also a major water-covering without damage.

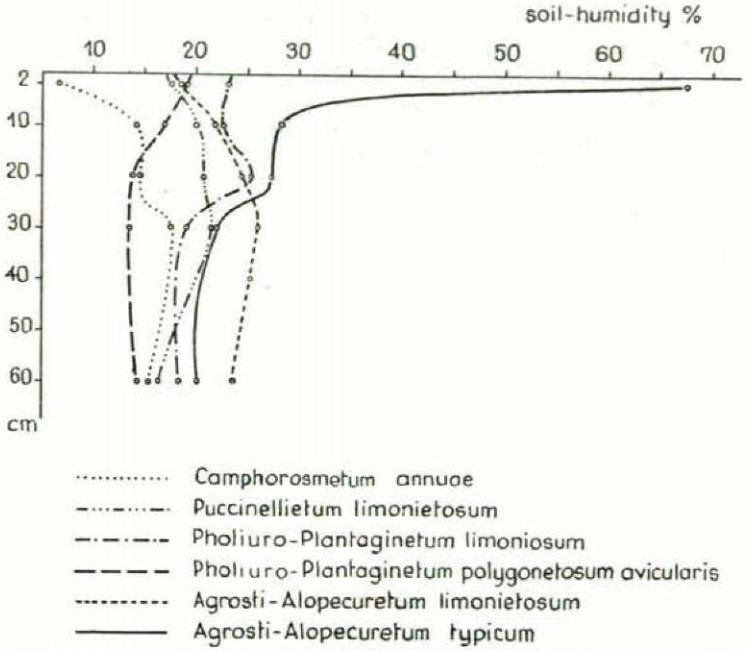

Fig. 6. Humidity content of soil-profiles of the different halophilic communities, May 21, 1964.

The minor and major lakes of the alkali soils of Orosháza, as the bed remainders of the river ancient-Maros have different, mainly solonchak soils, and also their vegetation has an appropriate development. The most extensive of these is the „Fehértó" of Orosháza. We discussed its vegetation relationship, its soil-ecology, and the chart-making results reflecting these in the Third Part of our Publication Series about the halophilic vegetation in Hungary (1965). The elucidation of the vegetation relationship of minor solonchak pools and backwater remainders belongs to our next tasks.

Common Summary of Parts III and IV

We performed synecologic investigations in the region of Orosháza from the three alkaline territories of waterloess origin of the Békés-Csanád ridge in the Hungarian south-eastern Alföld. Its solonetzes of meadow origin are the consequences of inundations of the here meandering ancient Ma-

ros-bed. Under the influence of the inland-water erosion the surface strata became eroded in different degrees. Depending upon the fact, in which degree the solonetz layers and first of all the layers of salt accumulation approach or get to the soil surface, resp. they fall victim partly or entirely, to the inland erosion, there are established different sub-types and alternatives of solonetz and meadow-soil on which alkaline vegetation coenoses come into being, repeating themselves systematically, and being characteristic of the concerning genetic soil unit. On the species composition of the single coenoses, and especially on appearance and lifetime of ephemerous species, mainly the alkaline *Trifolium* species, there are of decisive influence, apart from the physical and chemical effects of alkali soils, the meteorological conditions, first of all the quantity and distribution of spring and early summer rainfall, as well as the changes of air and soil temperatures. To registrate these changes in proper repetitions, we have continued our investigations for six years from 1959 (the year 1963, could be appreciated, by technical reasons, but partly). It could be observed that in the years when the April and May rainfall quantity attained the 40 mm monthly average, in proper soil circumstances, the alkaline *Trifolium* developed well, their lifetime being a function of the June rainfall quatity: a longer aridity and high temperature shorten lifetime of these one-year species and the meadow-lands and grazings get parched in some days.

Our observations cocerning mosaic complexes and zonation of the alkaline vegetations in the investigated territory have confirmed, in general outlines, our statements published about Hortobágy and conduced to further detail results.

1. *Astragalo-Poetum angustifoliae:* in meadow chernezem soil of higher level, being deeply salty, less exposed to an inland-water erosion. Its coenoses can be distinguished from the *Festucetum sulcatae tibiscense* of non-alkaline soil and from its degraded form, the *Cynodonti-Poetum angustifoliae.* There could be separated two sub-associations by its glykophilic, resp. halophilic differential species.

2. *Achilleo-Festucetum pseudovinae:* on meadow chernozem soil, being deeply saline on a shallower humus-level than the former one, having mostly an island-like appearance in the sea of solonetzes. In propitious condition it is sub-associated with meadow elements of *Alopecurus pratensis;* in xerothermic soils: sub-associated (= typicum) with *Achillea collina;* its degraded coenoses show *Cynodon* sub-associated transition towards *Cynodonti-Poetum.*

3. *Artemisio-Festucetum pseudovinae:* on its mosaic spots the inland-water erosion is increased its soil being therefore meadow solonetz becoming crusty steppe. Its sub-associations reflect the depth of solonetz layer: (a) *Achilleetosum* on meadow solonetz becoming moderately a steppe, (b) *Typicum,* (c) *Camphorosmetosum,* on solonchak meadow solonetz, becoming crusty steppe.

4. *Camphorosmetum annuae:* its mosaic spots taking place on slopes of former berm-like elevations where the saline layer is, under influence of erosion, on the surface these being the most extreme meadow solonetz soils of our territory, of strongly crusty solonchak. Some of its species are depending upon weather, *Matricaria chamomilla v. salina,* however, other ephemerous species, as *Comphorosma annus, Lepidium ruderale* could cut free from that.

5. *Puccinellietum limosae hungaricum:* its present soil-surface is somewhat under the original stratum of salt accumulation, thus it may be considered as a meadow solonetz of a weakly crusty solonchak Its *sub-associations* are: (a) *Alopecurus pratensis,* similarly differentiating the soil sub-type, being a soil-transition between zones of meadow solonetz and solonetz-like meadow soils; (b) *Typicum;* (c) *Polygonum aviculare,* in minor cavities, at summer-end with thin cracked mud-cover. (d) *Camphorosma* subassoc.: showing a transition towards meadow solonetz of highly crusty solonchak.

6. *Pholiuro-Plantaginetum:* an ephemerous alkaline coenosis, produced on alkali mud-soil; its sub-associations partly reflect the hydrographic relationships: *Alopecurus pratensis, Myosurus minimus, Plantago tenuiflora;* partly they let the conclusions be drawn concerning the degree of alkalization: *Polygonum aviculare-, Puccinellia limosa* subass.

7. *Agrosti-Alopecuretum* and its sub-associations form zones according to the degree and duration of water-covering of the meadow soils, becoming in smaller or higher degree of solonetz character: (a) *Eleocharis uniglumis (= typicum)* in the deepest soils, (b) *Limonium Gmelini* in drying up soils, (b_s) *Puccinellia limosa fac.* in soils becoming in a higher degree of solonetz character.

8. *Agrosti-Beckmannietum,* and

9. *Agrosti-Glycerietum* and their associated units formed their zones in meadow soils becoming of weakly solonetz character, similarly according to the degree of their being water-covered.

Selected literature

ANTIPOV—KRATAJEV, I. N.: 1960. — Szolonyec-talajok megjavításával kapcsolatos fizikai-kémiai vizsgálatok (Physiko-chemische Untersuchungen in Verbindung mit der Melioration von Solonec-Böden) — Agrokémia és Talajtan *9.* 163—178.

ARANY, S.: 1926. — A hortobágyi ősi szikes legelőkön végzett talajfelvételek (Soil investigation on ancient alkali grazings of Hortobágy.) — Kísérletügyi Közl.

ARNOLD, A.: 1936. — Beiträge zur ökologischen und chemischen Analyse des Halophyten-Problems. — Jahrb. f. wiss. Bot. *83.* 105—132.

BILYK, G. J.: 1937. — On the Vegetation of Saline and Alkalilands of the Middle Dniepr River Area. — Contr. to a Study of the Halophilic Veg. in the Ukr. SSR — Recueil Géobotanique 85—130.

BODROGKÖZY, GY.: 1962. — Die standortökologischen Verhältnisse der halophilen Pflanzengesellschaften des Pannonicum I. Untersuchungen an den Solontschak Szikböden der südlichen Kiskunság — Acta Bot. Acad. Sci. Hung. *8.* 1—37.

BODROGKÖZY, GY.: 1965 a. — Ecology of the halophilic vegetation of the Pannonicum II. Correlation between alkali („szik") plant communities and genetic soil classification in the Nothern Hortobágy. — Acta Bot. Acad Sci Hung. *11.*

BORBÁS, V.: 1881. — Békés vármegye flórája (Flora of County Békés.) — Math. Termt. Ért. *11.* 1—

BOROS, Á.: 1922. — Adatok Békés és Bihar megyék síkjainak flórájához (Beiträge zur Flora der Ebenen der Komitate Békés u. Bihar.) — Magyar Bot. Lapok *21.* 32—33

CHAPMAN, V. J.: 1960. — Salt marshes and salt deserts of the World. — Interscience Publishers. INC, New-York.

DONER, B.: 1943. — Az eperhere a szikes mezők értékes pillangósa. — *(Trifolium fragiferum* a valuable papilionacea of alkali meadows) — Köztelek *53.* 988—989.

GILLNER, V.: 1960. — Vegetations und Standortuntersuchungen in den Strandwiesen der Westküste. — Acta Phytog. Sueccica *43.* Götebg.

MAGYAR, P.: 1928. — Adatok a Hortobágy növényszociológiai és geobotanikai viszonyaihoz. (Data concerning the plant-sociological and geobotanical conditions of Hortobágy.) — Erdészeti kísérl. *30.* 63.

MAGYAR, P.: 1930. — Növényökológiai vizsgálatok szikes talajokon (Plant-ecological investigation on alkali soils.) — Erdészeti Kísérl. *32*. 75—118.
MÁTHÉ, I.: 1962. — A kamilla évjáratonkénti és tájankénti fejlődési és hatóanyagváltozásai — Die Veränderungen der Entwicklung und der wirksamen Substanz der Kamille nach den verschiedenen Jahrgängen und Gebieten.) Bot. Közl. *49*. 280—288.
NEILREICH, A.: 1866. — Aufzählung der in Ungarn und Slavonien bisher beobachteten Gefässpflanzen nebst einer pflanzengeographischen Uebersicht. — Wien.
RAPPAICS, R.: 1927. a. — A Közép-Tisza-vidéki szikes talajok növényszövetkezetei (Plant-communities of alkali soils in the region of Middle-Tisza. —) Debreceni Szemle *1*. 104—119.
RAPAICS, R.: 1927. b. — A sziki növényszövetkezetek tavaszi aspektusa (Spring aspect of saline plant-communities.) — Bot. Közl. *24*. 151—152.
RAPAICS, R.: 1930. — Az Újszász—Szegedi választóvonal (Dividing line between Újszász and Szeged) — Föld és Ember *10*. 48—54.
ŠMARDA, J.: 1952. — Přispěvek k poznani fytocenos slaných půd na jz. Slovensku. — Preslia *24*. 95—104.
SOÓ, R.: 1936. — Die Vegetation der Alkalisteppe Hortobágy. Ökologie und Soziologie der Pflanzengesellschaften. — Feddes Repert. *39*. 352—364.
SOÓ, R.: 1947. — Conspectus des groupements végétaux dens les Bassins Carpatiques. I. Les associations halophiles — Inst. Bot. de l'Université Debrecen.
SOÓ, R.: 1945. — Növényföldrajz (Plant-geography) — Budapest.
SOÓ, R.: 1964. — A magyar flóra és vegetáció rendszertani- és növényföldrajzi kézikönyve. I. (Taxonomic and Geographic Handbook of the Hungarian Flora and Vegetation Vol. I.) — Budapest.
SOÓ, R.—JÁVORKA S.: 1951. — A magyar növényvilág kézikönyve I. II. (Handbook of the Hungarian Vegetation. Vols I. II.) — Budapest.
SOÓ, R.—MÁTHÉ I.: 1938. — A Tiszántúl flórája (The Flora of „Tiszántúl") — Debrecen
'SIGMOND, E.: 1903. — Újabb tapasztalatok a szikes talajokról II. Minő összefüggés van a békéscsabai rét természetes flórája és a talaj sótartalma között. (Recent experiences about alkali soils. II. Interconnection between the natural meadow flora of Békéscsaba and soil-salinity) — Kísérletügyi Közl. *6*. 80—119.
STEFANOVITS P.: 1963. — Magyarország talajai (2. kiad.). (Soils of Hungary 2-nd ed.) — Budapest.
SZABOLCS, I.: 1954. — Hortobágy talajai (Soils of Hortobágy) — Budapest.
SZABOLCS, I.—JASSÓ, F.: 1959. — A magyar szikes talajok osztályozása — Klassification der Szikböden Ungarns — Agrokémia és Talajtan *8*. 281—300.
WALTER, H.: 1960. — Einführung in die Phytologie, Band III. Grundlagen der Pflanzenverbreitung (1. Teil Standortslehre) — Stuttgart.
WENDELBERGER, G.: 1950. — Soziologie der kontinentalen Halophyten vegetation Mitteleuropas. — Wien.